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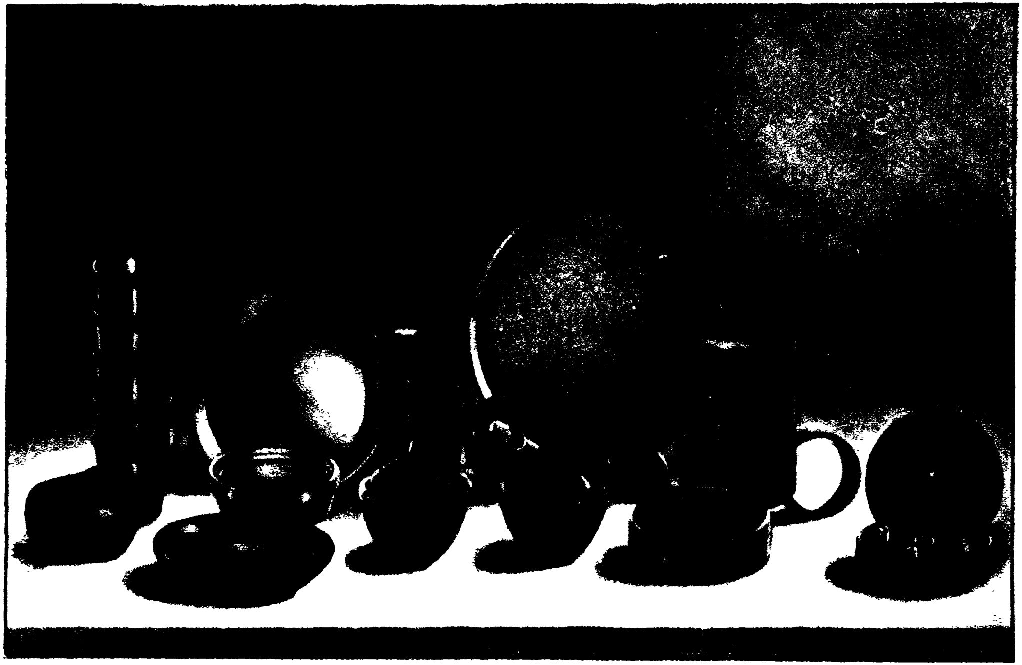
USES OF LAC



Samples of Shellac moulded articles made at the experimental Lac Factory of the Indian Lac Research Institute, Namkum, Ranchi, India.

USES OF LAC

BY

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AND

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PREFACE

During the last few years, a large number of enquiries from officials like the Directors of Industries and Forest Officers and also from private manufacturers and industrialists have been received by the Indian Lac Research Institute, asking for information regarding the possibility of increasing the uses of lac and shellac in India. The present booklet is a brief answer to these.

The uses of lac in America and Europe are so varied in number and methods that it is not possible to be exhaustive in the treatment of either within the compass of this booklet. Further, many of the descriptions available in literature are true only as regards the general procedure followed because every industry guards the details as trade secrets. It may, therefore, be well to emphasise that a strict adherence to the given description of the methods may not always yield the most satisfactory products, but a few trials with variations in details and improvements based on actual experience are the surest foundation for the successful establishment of any industry in which shellac is used.

Another important factor to be remembered before starting a new industry is to find out the potential market for the products and the cost of mass production. These remarks may be superfluous to most prospective industrialists but sometimes enquiries have been addressed for such information as is not within the sphere of a research institute to supply. The Indian Lac Research Institute can only offer general advice on the processes or solve any particular difficulty in an established shellac-consuming industry by 'ad hoc' researches on a laboratory scale, and cannot undertake the functions of an enterprising industrialist.

This booklet is largely a compilation of materials published in recent technical and scientific books and journals, and grateful thanks are due to all authors and publishers of the literature cited in the bibliography both for subject-matter and illustrations.

It has been estimated by competent dealers in shellac that the total annual consumption of lac in India is about 18-20 thousand cwt. or between 2 and 3% of the exported quantity. There would thus appear to be a potential expanding market for shellac consumption in this country with its progressive industrialisation, specially in view of the many useful properties of shellac, the applications of which have by no means been fully explored. Besides, the comparatively cheap price of the commodity is an effective guarantee against other resins, which, indeed, is shown by the increasing annual exports of seedlac and shellac.

In conclusion, the authors' thanks are due to various gentlemen, specially, Sir Bryce Burt, President, Indian Lac Cess Committee, Mr. A. J. Gibson, Special Officer, Lac Inquiry, Drs. Porritt and Bhattacharya, Mr. A. E. Lain and Mr. W. S. Lord, for useful criticisms and suggestions in preparing this booklet.

H. K. S.
S. R.

NAMKUM,
March, 1939.

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INTRODUCTION

The lac insect (Laccifer lacca, Kerr.) is a scale insect (*Coccidae* family and belonging to the bug order, *Hemiptera*) and is found to thrive on a variety of trees in India, Burma, Indo-China and Siam. The insect produces a red dye (laccaic acid) within itself, and an amber-like resin and white waxes round its body.

The antiquity of the uses of lac in India even from pre-historic times would be evident from the story in the Mahabharata that the Kauravas built a palace of lac (*Jatugriha*) and invited the Pandavas to live in it with the ulterior object of destroying them by setting fire to the palace. In 1563, Garcia de Orta described the uses of the lac-dye and the lac-resin in India. It is known from Ain-i-Akbari (1590) that a pigmented lac varnish was used in India for colouring screens made of bamboo-splits or reeds. Tavernier recorded in 1676 that in India the lac-dye is used for calico-printing and lac-resin for sealing-waxes and polishes. Even to the present day, lac is used in India for the manufacture of sealing-waxes, bangles, furniture polish, coloured wooden toys and as a filling for hollow gold and silver ornaments.

The various uses of lac are based on (*i*) its solubility in alcohol and the smooth and durable films left behind by air-drying a coating of such a varnish, (*ii*) easy fusibility on heating, (*iii*) its superior adhesion, (*iv*) hardness, (*v*) electrical insulation, (*vi*) resistance to the action of a wide range of organic solvents, and (*vii*) the binding properties of a solution of lac in weak alkalies like borax and ammonia. Synthetic resins superior to shellac in any of its various characteristics have been manufactured, but none of them possesses all the characteristics of shellac.

In early 19th century, the lac-dye was more widely used than the lac resin. But the practical disappearance of the dye as an important commercial product due to the discovery of aniline and alizarine colours, would be evident from the following table of exports of the dye:

(G. *Watt, Commercial Products of India*)

Year		Quantity Cwts.	Value Rs.
1868-69	...	17,748	7,96,655
1878-79	...	8,261	1,95,285
1888-89	...	333	8,038
1898-99	...	Nil	Nil

In India, the lac-dye was extensively used for colouring silk, wool and leather but the industry is now practically extinct due to the availability of more uniform and concentrated synthetic dyes in various colours.

The export figures for 1920-21 to 1937-38 are given in the following table and classified according to the grades of lac.

EXPORTS OF LAC AND SHELLAC FROM INDIA, 1920-21 to 1937-38.
(Financial year 1st April to 31st March)

From 'Annual Statement of Sea-Borne Trade of British India, etc.'

Year	Shellac		Button-lac		Seedlac		Sticklac		Other Kinds		Total
	Cwts.	%	Cwts.	%	Cwts.	%	Cwts.	%	Cwts.	%	Cwts.
1920-21	280,259	91	10,918	4	687	...	627	...	16,446	5	308,937
1921-22	379,944	87	10,724	2	1,824	...	882	...	41,560	10	434,934
1922-23	383,377	81	18,387	4	4,734	...	2,897	...	66,616	14	476,011
1923-24	397,147	83	16,863	3	19,100	4	1,800	...	50,761	10	485,671
1924-25	327,200	76	21,612	5	35,129	8	6,494	2	36,582	9	427,017
1925-26	416,590	77	21,678	4	37,424	7	22,783	4	41,449	8	539,924
1926-27	424,926	72	20,626	4	89,389	15	7,220	1	49,859	8	592,030
1927-28	404,367	74	18,042	3	54,694	10	9,130	2	57,351	11	543,584
1928-29	530,746	71	24,714	4	92,420	12	26,514	4	69,009	9	743,403
1929-30	498,252	74	24,175	4	68,033	10	6,861	1	72,093	11	668,914
1930-31	366,419	67	23,676	4	106,289	19	4,695	1	46,072	9	547,151
1931-32	297,012	64	18,164	4	104,657	22	12,841	3	31,050	7	463,724
1932-33	261,733	62	17,432	4	120,822	29	4,204	1	14,109	4	418,300
1933-34	529,075	72	19,100	3	152,214	21	6,872	1	23,727	3	730,988
1934-35	431,937	72	15,722	4	88,635	15	5,081	1	44,627	8	586,002
1935-36	284,532	58	29,373	5	125,842	26	7,270	2	40,564	8	487,581
1936-37	496,940	60	33,215	4	261,822	31	4,667	...	37,320	5	833,964
1937-38	409,226	62	24,012	4	187,484	28	508	...	43,441	6	664,671

It is difficult to estimate the total quantity of lac produced in India because the cultivation of lac is spread over a very large area, the number of trees cultivated varies from year to year, and yields depend on the host species, quality of brood used, season and locality. Assuming that the consumption of lac in India for industrial applications is small and constant, and that stocks of manufactured and unmanufactured lac in India are more or less on the same level every year, the annual export figures would give an idea of the production in India. The total exports increased from 43,740 cwt.in 1868-69 to 146,395 in 1898-99 and 308,937 cwt. in 1920-21. During 1936-37 the total was 833,964 cwt. There has been thus an irregular but definite increase in the exports during the last 70 years, in spite of the enormous development of the synthetic resin industry. It would appear, therefore, that although shellac is not taking its legitimate place in new industries, its time-honoured uses do not seem to have been superseded.

In the following chapters, an attempt has been made to present to the interested commercial public, a short but connected account of the various uses of shellac (and seedlac) in the order of their importance in the industries. The authors will fail in their duty if it were not stated at this stage that the booklet does not aspire to be a handbook for the specialist, but it is intended to stimulate new ventures and researches on lac.

CHAPTER I

GRAMOPHONE RECORDS

The gramophone record industry provides the largest single outlet for the consumption of shellac. Although it is difficult to obtain accurate statistics, it may be safely assumed that this industry consumes about 30—35% of the total shellac exported. The Indian consumption, however, on this head is of the order of 7000 maunds (250 tons).

The first practical talking machine was made by T. A. Edison in 1876 ; in this, the sound was recorded on and reproduced from the same cylinder of wax. It was difficult to duplicate the records from the original cylinder which was itself heavy and fragile and the quality of the sound reproduced was poor. In 1895, Emil Berliner perfected the first shellac disc record, as we know it *to-day*. Since then, the position of shellac in this industry has never been seriously threatened except when the price of shellac soared up to the dizzy heights of 150—300 rupees a cwt. It may not be out of place to briefly describe at this stage the several processes leading up to the manufacture of the gramophone record. The music from the studio is first recorded on a thick wax-disc rotating at a uniform speed on a turn-table. The recording stylus is tipped with sapphire which has a definite taper and sharpness, to obtain uniform results. The wax used in making the discs should be homogeneous in texture, neither so hard as to throw off small chips while cutting the groove nor so soft as to smear and must not change in physical texture on keeping. It is generally made up of several waxes, stearic acid or stearates, oleates, etc., the ingredients being carefully adjusted to ensure the cutting of a perfect groove. As the groove is being cut, a small vacuum sucker removes all the wax thrown up by the sapphire point. The sound-grooved wax known as the 'wax master' is carefully coated with graphite or bronze powder or gold. Specially selected finest graphite or bronze powder is carefully dusted by means of a soft pad of cotton wool. The more recent technique is to place the 'wax master' between two high tension electrodes in a vacuum chamber, the anode being of gold and the metal plate supporting the wax being the cathode. Pure metallic gold is deposited as an extremely regular and smooth coat over the grooved side of the wax. When this technique is adopted, the wax must be kept cold. Towards this end, only a thin coat of wax over a metal plate is used for recording and cold water is circulated under the metal plate while the gold is being sputtured, to prevent the wax melting under the heat of the process.

The wax surface coated with graphite, bronze or gold is electroplated with copper to a thickness of 0·04 to 0·05 inch. This copper plate, called the 'copper

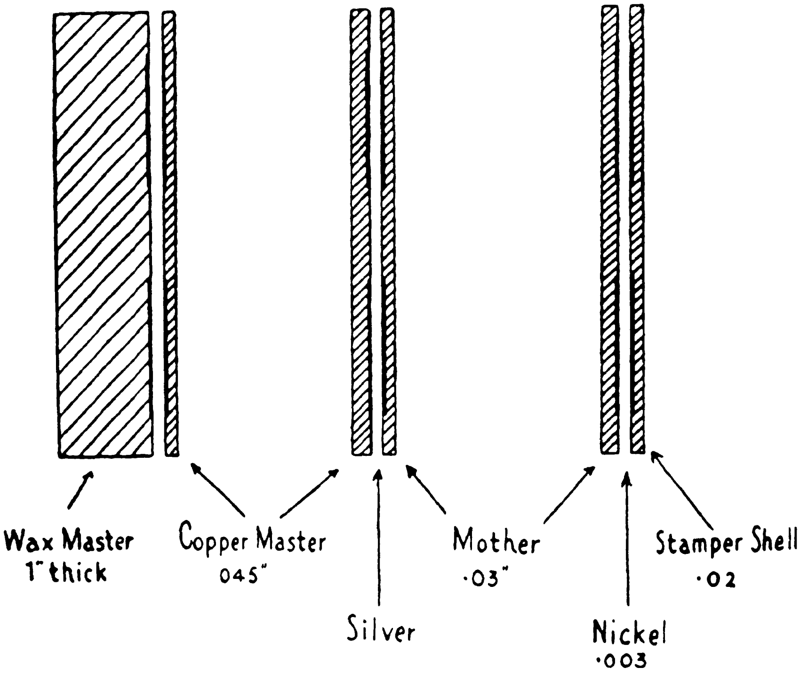

Fig. 1.

Diagrammatic Sketch showing Production of Stamper from Wax Master
(Courtesy Ernest Benn Ltd.)

master' is brushed with a silver cyanide solution called stripping solution and again electroplated with copper to a thickness of ·03 inch. This latter copper plate is called "Mother". By a repetition of the same process, a nickel-faced stamper is produced from the copper mother. In the case of nickel deposition, the stripper is a ½% solution of ammonium bichromate in water. The nickel-faced stamper is often, though not necessarily, chromium-plated and backed by a thicker plate before being used in the hydraulic press for stamping records. All the above processes require great skill born of experience over several years and also mean a large outlay of capital if successful results are to be obtained. A diagrammatic view of the several stages leading up to the preparation of the stamper is indicated in Fig. 1.

The gramophone stock *i.e.*, the composition used for manufacturing gramophone records contains 25—30% shellac. It is necessary for satisfactory results that the shellac used should have a low insolubles content, a high fluidity, long 'life under heat' and low wax content. A low percentage of impurities is preferred as insoluble particles may give rise to mechanical defects in sound grooves. When powdered shellac is melted in a glass tube and the tube is kept inclined at a definite slope and maintained at about 100°C. for a definite period, it flows down the sides, and the length of flow in that period is a measure of the fluidity of shellac on which depends its binding power for the fillers used in the stock. If shellac is melted in a test tube and kept hot and molten at about 150°C., it gradually thickens and hardens to a leathery mass. The time taken for the conversion of the fluid mass to a rubbery condition is termed the 'life under heat'. The longer the 'life' of a shellac, the greater are the facility in remoulding scrap and spew from previous pressings and ease of mixing the stock for a sufficiently long period between hot rollers (see *infra*).

When shellac is manufactured from raw lac (as is generally done by hot filtration through cloth in the Indian process), the insoluble impurities are removed but the wax which occurs to the extent of 5-6% of the lac melts together with the lac and is present in shellac, in a more or less dispersed form. An excess of wax in shellac causes wax-stains on records and sometimes spots of wax mark the grooves in the records, both of which are undesirable. The addition of 2—5% copal gum helps to disperse and fix the wax uniformly throughout the stock, but special grades of shellac containing 1—1·5% of wax manufactured by solvent processes, are now-a-days available.

A large part (60—70%) of the gramophone record composition consists of mineral fillers like barytes, kaolin, slate dust, silica, etc. Different manufacturers follow different formulae as regards the type and relative proportions of the fillers used, but the total amount of fillers does not vary much and the fineness

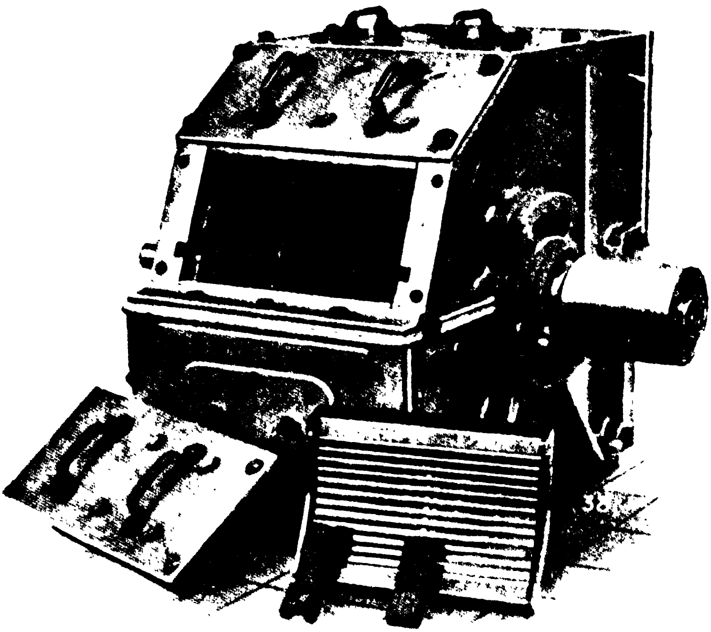

FIG. 2

SWING HAMMER BREAKER.
(Courtesy Ernest Benn Ltd.)

of grinding is to about 200—300 mesh. Generally, all shellac records are coloured black by the addition of 2—5% of nigrosine, lamp black, or bone black.

Shellac is generally ground to 80 mesh, the fillers and copal to 200 mesh and the carbon particles are less than 0·4 microns in size. It is difficult to grind shellac in the ordinary type of disintegrators with a serrated disc rotor since the heat generated by the friction would melt the resin and choke the speed of rotation. Two types which are generally used for grinding gums and resins are the hammer and the intercalating-pin types (Figs. 2 and 3). In these types of mills, the flakes of lac are shattered by impacts or discontinuous shearing with ample scope for air-cooling between shocks or shears.

The record stock is mixed to a uniform paste either between hot rollers moving towards each other at different speeds or in an internal masticator with a steam jacket· The plastic mass is pressed into sheets by a pair of internally cooled rollers moving at equal speed and cut into oblong slabs 7-8 oz. in weight and $\frac{1}{8}''$ thick for 10″ diameter records ; these slabs are then taken to the press-room for the actual stamping of records.

A typical semi-automatic press used in this industry is illustrated in Fig. 4. Its capacity is generally 80—100 tons pressure over the ram and the power is supplied through leads from a hydraulic accumulator. On the two faces of the press, platens are fitted with internally cored parallel channels or spiral channels having a central inlet and a peripheral outlet, as in Figs. 5*a* and 5*b*. The stampers (see *supra*) are fixed on these cored plates. A blank slab of composition is softened on steam-table, rolled up as a ball, placed on the lower stamper and the head or the upper stamper is lowered and locked by a turn of a handle. The following cycle of operations follows automatically:—(*a*) the ram of the press pushes up, exerting about ¾ ton pressure per square inch of the whole stamper surface, while steam at 90 lbs. pressure circulates during this period through the cored platens to retain the appropriate plasticity of the stock; (*b*) the steam supply to the platen channels is cut off and cold water is run through, and (*c*) the ram recedes. The top platen with the stamper fixed on it is now tilted back and the moulded record with some 'flash' is removed from the stamper. On so opening the platens, the water supply is automatically shut off and in its stead a current of steam flows through the cored channels in the platens, getting the press ready for the next record. The different stages are illustrated in Figs. 6, 7, 8 and 9. A complete cycle of operations for producing each record takes less than a minute. With skilled labour, the rejects due to faults are very few. The rejects, flash and trimmings are, however, ground up and mixed with a fresh batch of stock and used over again for moulding. Gramophone record moulding

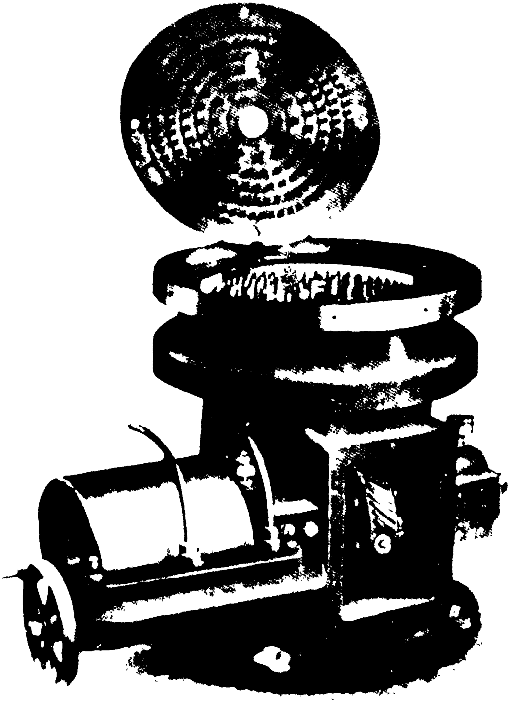

Fig. 3.

Kek Mill.
(Courtesy Ernest Benn Ltd.)

has been developed almost to perfection as regards economy of time, materials, and the playing qualities of the finished disc.

Laminated gramophone records, which have got only a limited market, are made by laying a thin coating of the usual shellac stock for gramophone records on either side of a disc of fibre board and impressing the sound grooves from a stamper as usual. These records, however, have not been very popular due to the fact that the central fibre core is affected by atmospheric humidity, leading to distortion and chipping off of the shellac layer.

Several synthetic resins have been tried as substitutes for shellac in the manufacture of gramophone records, and in all cases, so far, they have either proved unsatisfactory or prohibitively expensive.

Competent authorities estimate that the annual production of gramophone records is well over 200 million pieces, which would indicate that about 220,000 cwt. of shellac are consumed for this purpose per year. It is to be noted also that there is an ever widening market for gramophone records in the East.

Home recording *i.e.*, recording music or speeches at homes and reproducing them at will has a peculiar fascination, and the art has been tried to be developed time and again without much success. So far, gelatine, phenol-formaldehyde resins, and alloys of aluminium and copper have been tried as surfaces for sound-grooving, but each of the above has got its limitations.

Gelatine surfaces, though considerably hardened by formaldehyde, absorb moisture, whilst with phenol-formaldehyde resins, a distortion of the grooves takes place during the process of heat-hardening. With alloys, it is difficult to remove the strips and brushes coming out of discs while cutting the grooves. The criteria for a successful surface are initial softness at the time of cutting the sound grooves and absence of distortion during hardening followed by sufficient hardness to withstand needle scratch for a reasonably large number of times. Modified shellacs, or shellac-cellulose-ester combinations are being investigated at the Indian Lac Research Institute towards this development. Aluminium discs coated with special shellac compositions have been found to take good impressions when pressed in the hydraulic press in contact with a master stamper. Such records have the advantage of not being warped due to temperature changes, and their durability is satisfactory. Records made from such surfaces have given undistorted sound even after playing 100 times. If some arrangement could be established by gramophone companies to receive the metal discs back at a reasonable price, after a record has been played for a considerably long time, it is expected that considerable economy would be effected in this process.

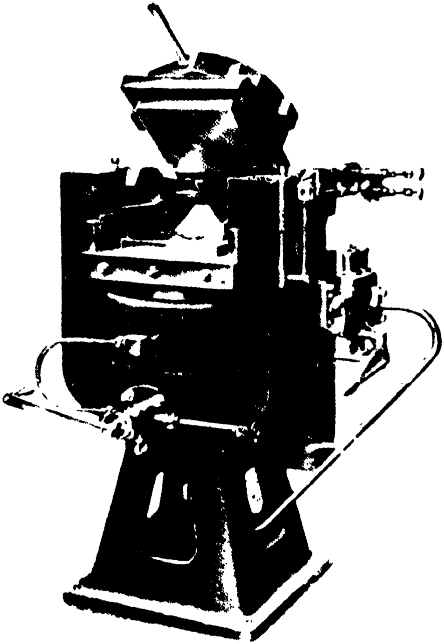

FIG. 4.
SEMI-AUTOMATIC GRAMOPHONE RECORD PRESS.
(Courtesy Ernest Benn Ltd.)

CHAPTER II

ELECTRICAL INSULATING MATERIALS

From the earliest days of the electrical goods manufacturing industry, natural minerals like mica and asbestos, vitrified materials like glass and porcelain and cellulosic materials like wood, cloth, paper, etc., are being used as various insulating components. The developments during the present century, and especially during the last 10 or 15 years, have been in the field of moulded composite insulations containing resinous binders, varnished cloth, paper and silk, laminated paper, cloth, etc., and insulating varnishes and enamels. Shellac is by far the best natural resin used as the organic binding material in moulded insulations. In recent years synthetic resins principally from phenol and formaldehyde have found increasing applications, partly at the expense of shellac, by virtue of their greater heat resistance and better mechanical strength.

Shellac possesses many useful properties for applications in the electrical industry, the most significant among which are:—

(1) High electrical insulating property;

(2) Excellent film-forming property of its varnishes;

(3) Good adhesion on mica, in which characteristic most other resins fail ;

(4) Freedom from surface carbonisation due to high-voltage silent discharges ;

(5) Non-conductance and non-extension of carbon tracks formed by sparking discharges.

Shellac is generally used in the manufacture of the following:—

(1) Moulded insulators like knobs, handles, arc shields, etc. ;

(2) Laminated paper boards and tubes ;

(3) Laminated sheet and moulded mica ;

(4) Varnished paper, cloth, and silk ;

(5) Insulating and finishing varnishes for small coils ;

(6) Insulating cements.

Shellac moulded Articles

Shellac moulded articles are prepared more or less on the same lines as gramophone records but with different fillers like wood flour, asbestos, kaolin, etc. These mouldings are generally suitable for use at temperatures below 60°C. Switch handles, switch bases and boards, terminal boards, terminal heads, push-buttons, telephone handles, etc., could be made

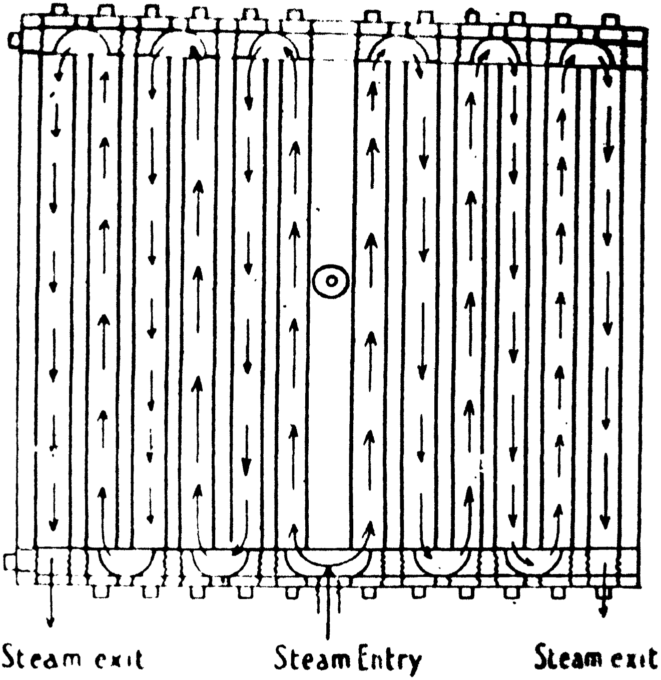

FIG. 5a.
STEAM-HEATED & WATER-COOLED PLATENS (EARLY TYPE).
(Courtesy Ernest Benn Ltd.)

with shellac as the binding material. The following are a few typical compositions generally used:

1.	Shellac	24	Parts
	Copal	8	"
	China clay	43	"
	Felspar	20	"
	Lampblack	5	"
2.	Shellac	25	"
	Asbestos	70	"
	Lampblack	5	"
3.	Shellac	50	"
	Wood flour	45	"
	Lampblack	5	"

In the past, all these parts were invariably made of such or similar shellac compositions, but in recent years, synthetic resins are being substituted for at least some of these. The reasons for such a substitution were mainly the higher price of shellac as compared with synthetic resins in the past and partly the economy in moulding operation and the superior mechanical and thermal properties of the latter. With the present low prices of shellac, interest in its use for electrical goods is veering round, and intensive research will go a great way to rehabilitate the somewhat lost position.

Shellac-bonded mica products

Mica is one of the best electrical insulating materials known, and India exports about 5,000 tons of high-grade mica every year. The electrical industry consumes most of the mica exported, after preparing composite sheets or shaped articles with the help of shellac as the adhesive bond. Mica splittings are at first freed from dirt and magnetic impurities, and classified into uniform sizes by running through vibrating sieves. The sized splittings are then spread out in a single overlapping layer either by dropping them from a tower or lifting up on a perforated plate by vacuum suction and dropping them on another surface by removing the vacuum. A 10—15% solution of shellac in industrial spirit is sprayed on the surface and another layer of mica is put on. The process is repeated until the requisite thickness has been built up. Sometimes, instead of a varnish spray, finely powdered shellac is dusted on. When a varnish is used, the stack is dried in a vacuum oven at 100°C. for one or two hours to remove the solvent. The dried stacks are compressed in heavy hydraulic presses at 160°C. and about 1,000 lbs. per square inch pressure for one hour, cooled without releasing the pressure, and then removed from the press. Each press could handle several sheets at a time (Fig. 10) by means of a requisite number of intermediate hot plates between the top and bottom platens of the press. The pressed sheets are subsequently milled for securing the

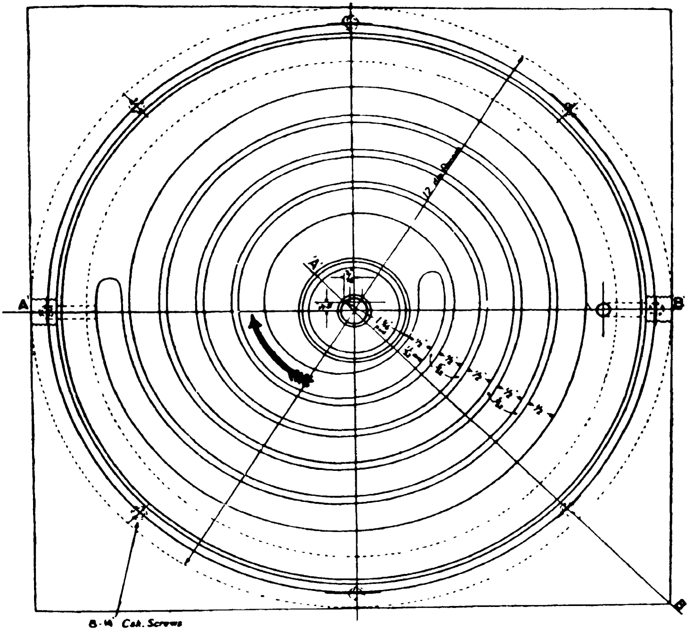

Fig. 5b.

Platen with Spiral Steam Channels (Modern Type).
(Courtesy Ernest Benn Ltd.)

desired limits of thickness. Hard micanite plate of this type is used for commutator segments, insulating barriers, etc.; it contains about 5% of shellac on the total weight of the sheet. Mica sheets bonded with 10—12% of shellac are moulded into different shapes for commutator cones, 'V' rings, slots, troughs, tubes, etc. Micafolium consists of a thin layer of mica splittings stuck on to rolls of paper by a shellac varnish. An ammoniacal solution of shellac is sometimes used for bonding mica, with greater economy of cost.

Miscellaneous

Shellac-bonded paper products are used as sheets, rods, and tubes for insulation purposes (Figs. 11 and 12). The process of manufacture consists in leading the paper successively through a varnish bath, a drying oven and a calendering or rolling machine. The viscosity of the varnish, the speed through the varnish bath, temperature of the oven and duration of heating have all to be carefully controlled. The laminated insulating boards of paper and cloth are used for transformer insulation, high tension terminals, bushings, etc. Shellac-bonded paper products generally withstand 60°C. but special grades obtained by proper heat-cure resist up to 120°C. The heat curing process, which is gradually effected, converts shellac from a comparatively soft resin to a tough mass of higher softening point by further polymerisation. Shellac varnishes are very satisfactory for impregnating and finishing small coils for instruments, meters, small induction motors, etc. Small amounts of castor oil or Venice turpentine are added to the varnishes to impart greater flexibility.

A shellac solution in methylated spirit mixed with mineral fillers such as mica, asbestos, talc, etc., is employed as an insulating cement for fixing metal caps to bulbs. The use of zinc oxide as a filler results in a more heat resisting cement.

CHAPTER III

PROTECTIVE AND DECORATIVE FINISHES

Wood Work

Shellac is an article of many uses in the woodworking industry. It is used as a grain filler, hard stopping, knotting, varnish, polish and reviver. The use of shellac dissolved in spirit as 'French Polish' has been known for several centuries and is still practised throughout the world whenever a really high class finish on wood is required.

Cracks and crevices in wood work are filled and smoothed out by a composition made up by melting together the following:—

Shellac	... ...	290 gms.
Rosin	... ...	4 „
Beeswax	... ...	4 „

A thick shellac varnish, containing as much as 50 parts of shellac in 100 parts of spirit, may be applied over the surface of open-grained wood work and sandpapered after drying, to close up the grain. A varnish containing 20-30 parts of shellac in 100 parts of methylated spirit is taken on a cloth-pad and rubbed over wood work to obtain a bright polish. Venice turpentine, gum mastic, gum elemi, castor oil, linseed oil etc., added to the varnish improve the elasticity of the dried film. For cheap work and mass production, shellac varnish could be applied by brushing or dipping.

Wooden flooring can be stained and polished by the application of shellac dissolved in methylated spirit containing a small amount of the requisite shade of a spirit-soluble dye. A typical formula is:

Shellac ...	... 28	parts
Pale linseed oil	... 8	,,
Spirit ...	... 100	,,
Dye ...	... 0·5—2·0	

A scratched and faded wooden floor can be renovated by mopping with a 10% solution of shellac in spirit which removes the dirt and leaves a thin coat of shellac.

A water emulsion used for floor polishing consists of:—

Shellac ...	... 36	parts
Carnauba wax	... 80	,,
Water ...	... 800	,,
Borax ...	... 7	,,
Soap ...	... 9	,,

The shellac and wax are first melted together and then emulsified in the water containing soap and borax in solution. Pigmented shellac varnishes are used as bobbin enamels, and anti-fouling and anti-corrosive paints for ship-bottoms.

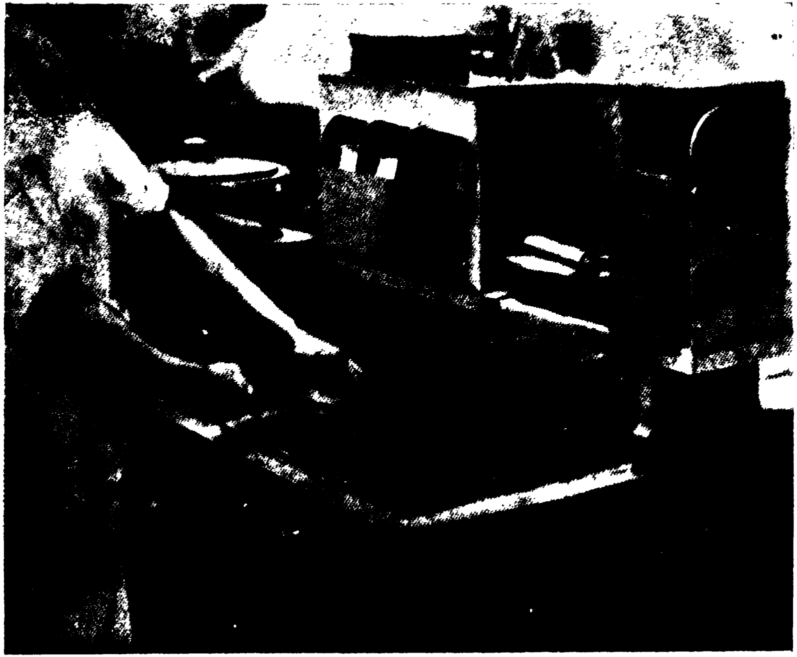

Fig. 6.

Gramophone Record Stock being softened on a Hot Plate.
(Courtesy Ernest Benn Ltd.)

Bobbin enamel

Shellac	120	parts.
Alcohol	180	,,
Castor oil	1	part.
Pigment	20	parts
Toluene	2	,,

Anti-corrosive paint

Shellac	17	parts.
Alcohol	160	,,
Pine oil	14	,,
Zinc dust	22	,,
Zinc oxide	60	,,

Anti-fouling paint

Shellac	32	parts.
Alcohol	150	,,
Pine oil	24	,,
Zinc oxide	33	,,
Ferric oxide (Red)	33	,,
Mercuric oxide	15	,,

A grinding Japan for coach finishes is prepared as follows:—

Shellac	10	lbs.
Linseed oil	4·5	gallons.
Lead oxide	20	lbs.
Manganese dioxide	1	lb.
Turpentine	12	gallons.

The oil is first cooked with red lead and manganese dioxide at 240°F. and raised to 400°F. with stirring ; shellac is added gradually in small portions and finally thinned with turpentine and the supernatant layer decanted. Pigments of various desired shades could be ground in this medium for preparing durable coach varnishes.

Metals

Ornamental brassware or brass parts of scientific instruments are protected from tarnishing by coating with a thin shellac varnish, drying in a warm atmosphere and baking at 100°C.

For damp surfaces where no other varnish will adhere easily, shellac varnish has been found to dry quickly with good adhesion.

Coloured lacquers for tin-foil, used for wrapping cheese, chocolates, etc., are prepared by grinding suitable pigments in shellac spirit varnish and subsequently adjusting the shade by coal-tar dyestuffs.

Paper

Shellac varnishes are used in treating paper for obtaining glossy, coloured or water-proof surfaces.

In the manufacture of playing cards, a thin coating of bleached lac varnish or a fine dust of bleached lac is applied before calendering the blanks to give a glossy, non-tacky, moisture-resistant finish. Similarly, in the manufacture of glossy stained paper and water-proof papers, shellac solutions in spirit or aqueous borax are used.

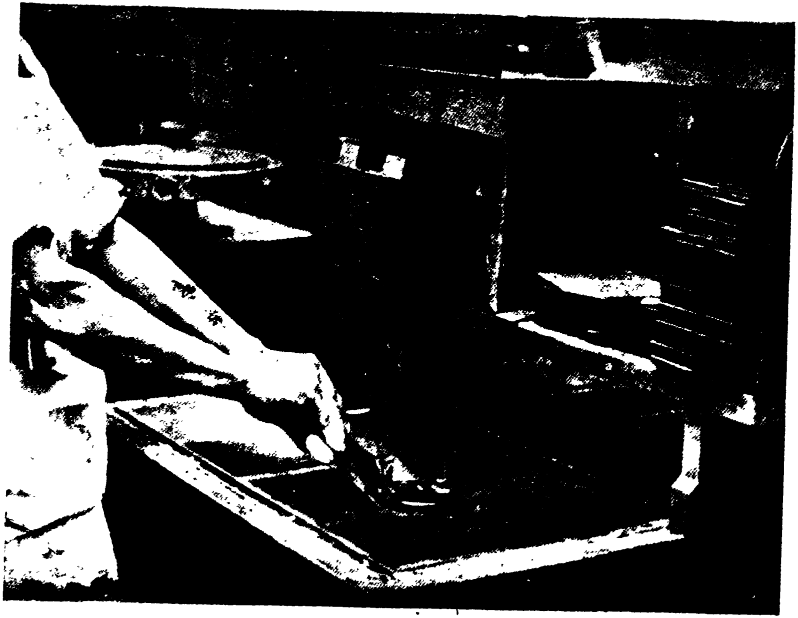

FIG. 7.

SOFTENED GRAMOPHONE RECORD STOCK BEING TAKEN UP BEFORE CHARGING INTO THE PRESS.
(Courtesy Ernest Benn Ltd.)

Two typical compositions for water-proofing are:

Shellac	5	parts.	Shellac	3	parts.
Water	10	,,	Water	20	,,
Borax	1	,,	Ammonium hydroxide	1·3	,,

Artificial leathers are prepared by coating tough grades of paper with glycerine, beeswax, colour, glue and shellac solution of borax and finally finishing with shellac-spirit varnish.

Leather

Shellac is the most important material in the general finishing of boots, shoes and other leather goods. Provided the de-greasing of the hides and skins is thorough and the final washing has removed all traces of salt used in the course of cleaning, shellac dressings maintain a perfect gloss. The superiority of shellac shoe-dressings is due to their adhesion, softness, flexibility and gloss, when properly formulated with softer resins, soaps and plasticisers. A few typical formulæ are given below:—

Fine Tan Dressing

Shellac	80	lbs.
Borax	22	,,
Water	36	galls.
Olive oil soap	4·5	lbs.
Potassium stearate	1·5	,,
Acetone	5	,,
Sassafras	1·25	,,

Split and kip dressing

Shellac	100	lbs.
Borax	25	,,
Water	52	galls.
Tallow soap	14	lbs.
Soluble oil	0·75	gal.
Nigrosine	10·5	lbs.

Box-calf spirit dressing

Bleached lac	5	lbs.
Industrial spirit	3	galls.
Methyl cyclohexanol	0·25	gal.
Venice turpentine	1	lb.
Nigrosine	1	,,
Lemongrass oil	0·25	gal.

Spirit dressings are costlier than those made in borax and water but they are more serviceable in preventing 'spue' *i.e.,* the development of greasy and dull streaks and whitish-grey exudations on finished shoes due to unsatisfactory leather used.

Cloth

In the manufacture of rubberised cloth, oil cloth and leatherette, a final coat of thin shellac varnish is used to render the surface non-tacky.

Nitro-cellulose lacquers

Nitrocellulose lacquers have come into prominence since 1914 when they were first used in 'dopes'

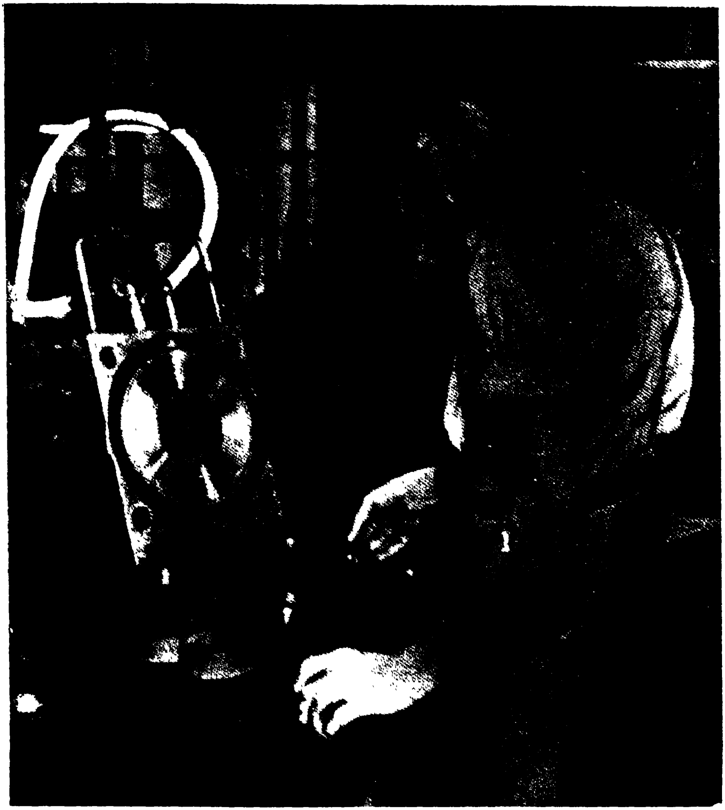

FIG. 8.

REMOVING A GRAMOPHONE RECORD FROM THE PRESS.
(Courtesy Ernest Benn Ltd.)

for aeroplane fabrics. During the last 15 years, the manufacture of nitrocellulose lacquers has made phenomenal progress due to the development of low viscosity types, a wider range of more useful and cheaper solvents and plasticisers, and improvements in the methods of formulation and application. Shellac has got a place in this progress as a very suitable addition material in the manufacture of the best types of lacquers.

A solution of nitrocellulose alone forms on drying and evaporation of the solvent, a brittle, non-adhesive, dull film. Shellac is added to such solutions to increase the total solid contents without appreciably increasing the viscosity so that the lacquer may have better adhesion and gloss. Nitrocellulose lacquers have mainly replaced the older oil-varnishes but also, especially in Germany and America, shellac wood polishes used in the furniture industries. But along with the loss of consumption of shellac in the field of wood polishes, there has been a large increase in the manufacture and uses of nitrocellulose lacquers, in the best types of which shellac forms an essential constituent.

The formulation of nitrocellulose lacquers is a highly specialised industry requiring great care in the choice of materials as regards their quality, proper balancing of the proportions of solvents and diluents and correct mixing. Nitrocellulose solutions with low viscosities are used for high-grade enamels and wood lacquers. Two typical formulæ are as follows:

1.	Low viscosity pyroxylin (2 to 1 with spirit)	16 parts.
	Butyl alcohol	10 ,,
	Glycol monoethyl ether	14 ,,
	Toluol	12 ,,
	Castor oil	5 ,,
	Tricresyl phosphate	3 ,,
	Shellac (40% solution in spirit), wax-free	40 ,,
2.	Nitrocellulose (Low viscosity)	16 oz.
	,, (high ,,)	4 ,,
	Dammar varnish	1 pt.
	Shellac varnish	2 ,,
	Butyl acetate	1½ ,,
	Denatured alcohol	3½ ,,
	Methylacetone	1 ,,
	Castor oil	2 oz.

In formula (2) dammar solution is obtained by dissolving 10 lbs. of the resin in a gallon of solvent (15% ethylacetate, 15% acetone and 70% benzol) precipitating the wax by adding ¾ gallon of wood alcohol and using only the clear solution. The shellac solution is prepared by dissolving 4 lbs. in a gallon of solvent (75% denatured alcohol and 25% butanol).

An undercoat of ordinary shellac varnish over wood surfaces fills the pores and seals the wood-dye

FIG. 9.

A FINISHED GRAMOPHONE RECORD.
(Courtesy 'Modern Plastics'.)

so that the latter does not bleed through a subsequent coat of nitrocellulose enamel, because the dry shellac film is only slightly soluble in the ordinary lacquer solvents.

Wax-free shellac is generally used so as to obtain clear solutions and bleached lac is used for pale lacquers.

CHAPTER IV

THE HAT INDUSTRY

Shellac is used in the manufacture of felt, silk and straw hats. Shellac spirit varnish is used as a sizing for felt hats due to its high stiffening qualities. Three pounds of bleached lac is dissolved in a mixture of 3·75 gallons of industrial alcohol and 1 pint butyl alcohol. If the solution is allowed to stand for a time and only the clear supernatant solution or filtered solution is used, the surface of the hat would be brighter and more glossy than if a turbid varnish is used.

For the sake of cheapness, acqueous borax and ammoniacal solutions of shellac are used. These may be prepared by dissolving 11 lbs. of borax in 5 gallons of boiling water, slowly adding 10 lbs. of shellac with stirring and diluting the solution with 15-20 gallons of water. Sometimes a gallon of thick shellac varnish in spirit is added to 3 gallons of dilute ammonia. In this case, 400 c.c. of strong liquor ammonia are added to a solution of 4 lbs. shellac in ½ a gallon of spirit, stirred quickly, and diluted with 3 gallons of water containing 150 c.c. of strong liquor ammonia.

In the manufacture of silk hats, shellac solutions are used for stiffening the fabric framework inside the hats.

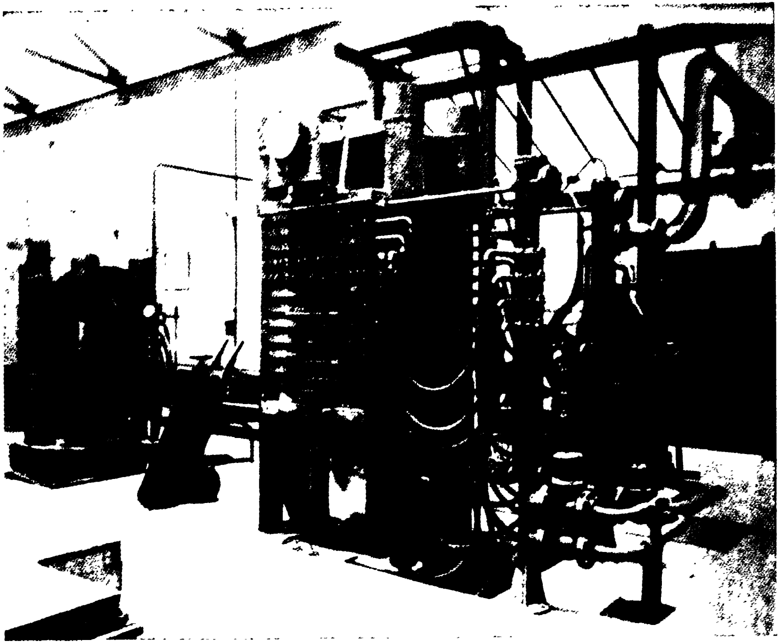

Fig. 10.

Hydraulic Press for Laminated Boards.
(Courtesy Ernest Benn Ltd.)

Straw hats are finished with a thin bleached lac or shellac solution suitably plasticised and modified with other materials. The following solution is cited as an example:—

Bleached lac	2	lbs.
Sandarac	½	,,
Manila copal	½	,,
Castor oil	55	c.c.
Methyl alcohol	2	gallons.

The wide use of shellac and bleached lac in the hat industry is due to their following properties:—

1. Softness when warmed and stiffness on cooling;
2. Does not stick to the shaping block;
3. Non-web-forming between the inter-spaces of felt-fibres or straw;
4. Improved appearance on buffiing or polishing.

CHAPTER V

SEALING-WAX MANUFACTURE

During the Middle Ages, coloured beeswax was used for closing letters and envelopes and for impressing seals on documents. In the 16th century, the use of lac in sealing compositions was introduced in Europe by Spanish merchants who carried on trade with the East.

Although the cheapest sealing-waxes are made of pitch, rosin and fillers like clay, brick-dust, etc., all medium and high quality sealing-waxes are made of shellac, finely ground pigments, barytes, kaolin, etc. Shellac confers on the sealing-wax, good adhesive properties, gloss and good reproduction of delicately engraved seals. As regards colour, red is generally preferred and genuine vermilion (red sulphide of mercury) which is comparatively very costly is often used. Other red pigments and mixtures of pigments and dyes can also be used but the genuine vermilion colour cannot be exactly reproduced by any other colouring material. The advantage in using vermilion is that its colour is stable to heat and light. Rosin is generally added to partly replace shellac in view of its comparative cheapness. Turpentine and Venice turpentine are added to render the sealing-wax less brittle. Among the various fillers used, barytes is

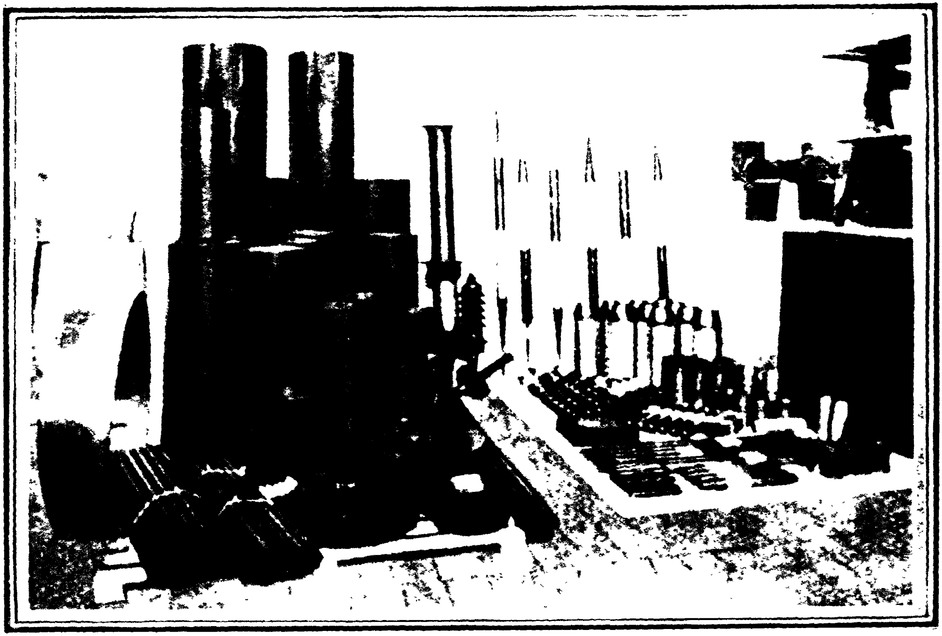

FIG. 11.

LAMINATED PAPER PRODUCTS.
(Courtesy Ernest Benn Ltd.)

preferred due to its high density. For special fancy sealing-waxes, fragrant balsams and essential oils are used in small amounts to mask the odour of molten lac at the time of sealing; and mica bits or coloured tin-foils are used to give a sparkling effect. The softening point of sealing-waxes can be adjusted within wide limits by varying the proportions of the resinous constituents. Generally the sealing waxes used in Europe and America have lower softening points than those used in India. For tropical conditions, the softening point should be so adjusted that a seal is not defaced on exposure to 55°C. for 5 hours. A high grade sealing-wax could be made up as follows:—

Shellac ...	... 45	parts.
Rosin ...	... 15	,,
Turpentine	... 5	,,
Barytes ...	... 35	,,
Vermilion ...	... 5	,,

Shellac, rosin and turpentine are first melted together in an enamelled or aluminium vessel to a homogeneous condition and then finely powdered, dry barytes and vermilion are added and stirred into the melt. When the composition becomes thin and free flowing, it is poured into brass moulds of the desired shape and size. The sticks are taken out after the mould is cold and are then polished by gentle warming in radiant heat.

CHAPTER VI

GRINDING WHEELS

Grinding wheels are made up of abrasive particles held together by a binding medium. The abrasives generally used are as follows:—

(*a*) Corundum or naturally occurring sesquioxide of aluminium ;

(*b*) Emery, an impure variety of corundum associated with magnetite ;

(*c*) Artificial corundum, prepared by fusing bauxite in a special arc-type electric furnace ;

(*d*) Carborundum or silicon carbide, prepared by fusing sand, coke and saw-dust in the presence of a flux, usually salt, and crushed to the required grain-size.

Grinding wheels containing definite sizes of abrasive particles are made, depending on the type required *i.e.*, for rough or fine grinding.

The bond used varies with different types of wheels and a few important ones are as follows:—

(*a*) Vitrified clay.
(*b*) Silicates.
(*c*) Shellac.

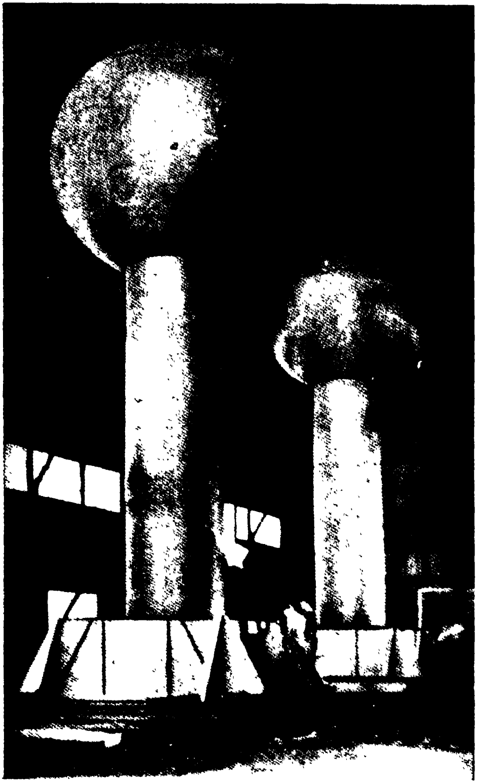

FIG. 12.

TUBES AND SPHERES OF SHELLAC-BONDED PAPER FOR AN ELECTROSTATIC GENERATOR.
(Courtesy 'Modern Plastics'.)

(*d*) Rubber.

(*e*) Bakelite.

Vitrified wheels are made by first pressing a mixture of clay and an abrasive and then fusing them in kilns at high temperatures. Silicate wheels are mixtures of sodium silicate and abrasives baked at low temperatures. Rubber wheels are prepared by masticating raw rubber with vulcanising agents and abrasives and cutting the sheets to size. Bakelite wheels are prepared similarly and cured under pressure

In the manufacture of shellac grinding wheels, (Fig. 13), the abrasive powder used is of one uniform fineness or two sizes, in a definite proportion, mixed thoroughly. The powder is dried at 170°C. till free of all moisture and mixed with 5-15% of shellac, the percentage of the latter depending on whether soft or hard wheels are required. The mixing is carried out quickly in 2-5 minutes at 170°C. as otherwise the lac may harden and loose its binding and covering property.

The mixture is quickly spread out in a thin layer on a cold surface. The lumps are coarsely powdered, charged into appropriate cast iron moulds, heated till slightly plastic and pressed at 1 ton per square inch and cooled under pressure. The wheels are then baked in ovens at 100°C. for several hours and the baking is continued at gradually increasing temperatures until 170°C. is reached within 48 hours. The longer the baking process and the more gradual the rate of increasing the temperature of the oven, the better are the final properties of the wheels.

Shellac grinding wheels have considerable elasticity and are specially preferred when thin wheels or wheels meant for highly finished surfaces are required.

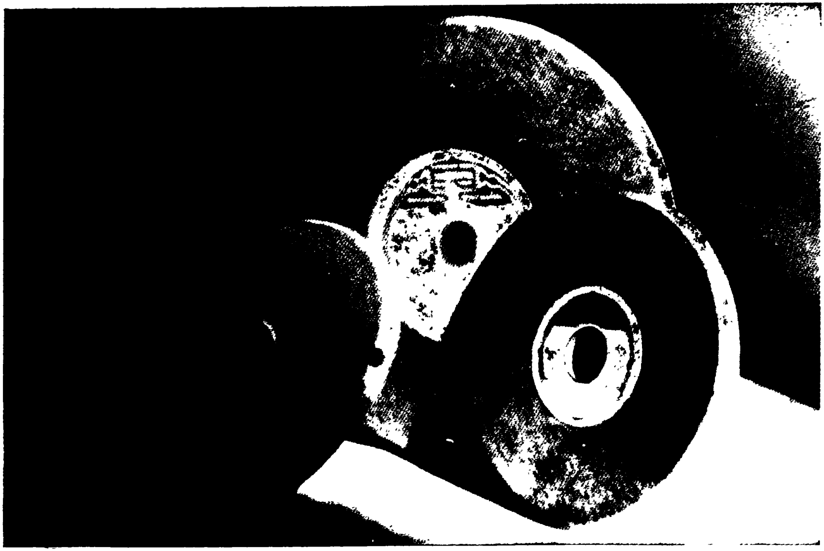

FIG. 13.

SHELLAC-BONDED GRINDING WHEELS.
(Courtesy 'Modern Plastics')

CHAPTER VII

MISCELLANEOUS APPLICATIONS

Shellac finds a large number of small applications in practically every major industry. A few typical examples may serve to illustrate the wide range.

1. A *shellac cement* is used whenever strong adhesion to wood, metal, glass, paper, leather or concrete surfaces is required. As examples, it may be mentioned that these are used for basing electric bulbs to metal caps, or fixing bristles in brushes or cementing small parts of scientific instruments. The procedure is first to warm the surface, pour the molten or pasty cement, fix by gentle pressure and harden by baking at moderate temperatures.

Glass to metal cement

Shellac	15 parts.
Pine tar	8 ,,

Cement for Glass-ware

Shellac	100 parts.
Beechwood creosote ...	10 ,,
Turpentine ...	4 ,,
Ammonia	1 ,,

Rubber Cement

India-rubber (finely chopped)	100 parts.
Rosin	15 ,,
Shellac	10 ,,
Carbon disulphide	Sufficient to dissolve the ingredients.

Linoleum Cement

Shellac	275 lbs.
Industrial alcohol	74 galls.
Crude rubber	1·5 lbs.
Petrol	9 galls.
Whiting	896 lbs.

Cement for Munition Work

Shellac	7·5 lbs.
Alcohol	8·0 ,,
Stockholm tar	5·0 ,,
Venetian red-oxide	20·75 ,,

Excellent transparent water-clear adhesives can be prepared from aleuritic acid, a component of hydrolysed lac:—50 grams of aleuritic acid are at first condensed with 15 grams of phthalic anhydride at 180°—190°C for 20 minutes. A small addition of glycerine (about 10% on the weight of aleuritic acid taken) facilitates the reaction and prevents the volatilisation of phthalic anhydride. The condensed mass is then reacted with 75 c.c. of 40% solution of formaldehyde for 2 hours at 120°C. The resulting mass is dissolved in butyl alcohol and 12 grams of urea are added in small portions and the whole refluxed for a further period of 2 hours, after which the solvent and water are removed by distillation under reduced pressure. The clear viscous resin left behind can be directly used as adhesive, or in the form of a solution in mixed solvents (*e.g.*, alcohol and benzene or toluene, 1 : 1). In order to render the adhesive water- and heat-resistant, a short baking at 100°C for 15 minutes is necessary.

2. Water-proof inks and certain types of printing inks contain shellac.

Water-proof Ink

Shellac	65	parts.
Dilute ammonia ...	500	,,
Phenol	1	,,
Borax	3	,,

In the above formula, the shellac is first dissolved in ammonia and the wax is removed by shaking with petroleum ether before adding phenol and borax.

Transparent Aniline Ink.

Bleached lac (wax-free)	44	parts.
Methylated spirit ...	44	,,
Acetic acid ...	2	,,
Dye	10	,,

A variety of inks could be prepared by dissolving shellac in aqueous solutions of borax and adding suitable dyes and pigments.

3. For the manufacture of cheap bangles, fine lac dust is mixed with an equal amount of clay and a small amount of pigment, melted in a hot plate over a charcoal fire and moulded into circular rings by a deft manipulation with the hand. The rings are taken up on a cylindrical pole, warmed slightly and impressed with brass moulds with various engravings. Coloured tin-foil is sometimes laid on before impressing the design.

4. Wooden toys are turned on hand-lathes and coated with coloured lac in many parts of India. Sticks of coloured lac are prepared by melting a small quantity of good quality shellac or button lac with a small amount of pigment (usually orpiment, ochre, indigo, ultramarine blue, etc.) and thoroughly homogenising it by repeatedly beating the soft and plastic mass by means of a hammer on a concave stone surface. It is then rolled up into small sticks. As the wooden article is being rotated on the hand-lathe, the stick of coloured lac is pressed against its surface when the lac is melted by the heat of friction and a thin beautiful coating is left on the article.

Many years ago, a variety of highly artistic products were produced by the skilful application of mixed colours, embedding mica flakes or tin-foil, engraving, inlaying etc., but now-a-days simpler and easier methods are only followed and apart from toys, articles of general utility like penholders, walking sticks, bedstead legs, etc., are also lacquered in several parts of India.

5. In certain parts of India powdered sticklac is used for internal administration as a medicine for diseases like haemostosis, tuberculosis, etc. (Current Science Vol. IV. No. 6). It is also known that powdered sticklac is soaked in *til* oil and exposed to sunlight for several days and the oil treated thus is used as an embrocation in case of rickets, rheumatism, etc.

It is difficult to obtain accurate details about the medicinal uses of lac since these are practiced by doctors of old schools of medicine in the remote interior parts of the country.

6. The natural lac dye, the production of which was the *raison d' etre* of the lac industry in former days, has been almost completely replaced by the synthetic dyes although small quantities are being still used for dyeing woollen carpets and silk-yarn in certain parts of India.

7. Small amounts of shellac are also used in pyrotechny and manufacture of munitions.

CHAPTER VIII

RECENT RESEARCH DEVELOPMENTS

The Indian Lac Cess Committee has established Research Institutions in England and India (Namkum near Ranchi) and had subsidised lac research in America. Annual reports of the progress of researches, research bulletins on particular investigations, handbooks of general information, etc., are issued through the above agencies from time to time. It has been felt that by improving the properties of shellac it can be made more suitable for the existing industrial applications or may find new uses and provide larger markets. A brief summary of research developments along these lines follows.

Manufacture of Lac

The process of shellac manufacture (*vide* Appendix I) is essentially a further purification of washed lac by means of hot filtration through cloth. The process involves a small loss of lac which adheres to the impurities inside the cloth-bag and to the bag itself. One of the methods of increasing economy of manufacture is to grind the sticklac in a ball-mill (Fig. 14) in the presence of a weak solution of alum in water and decant off the water which

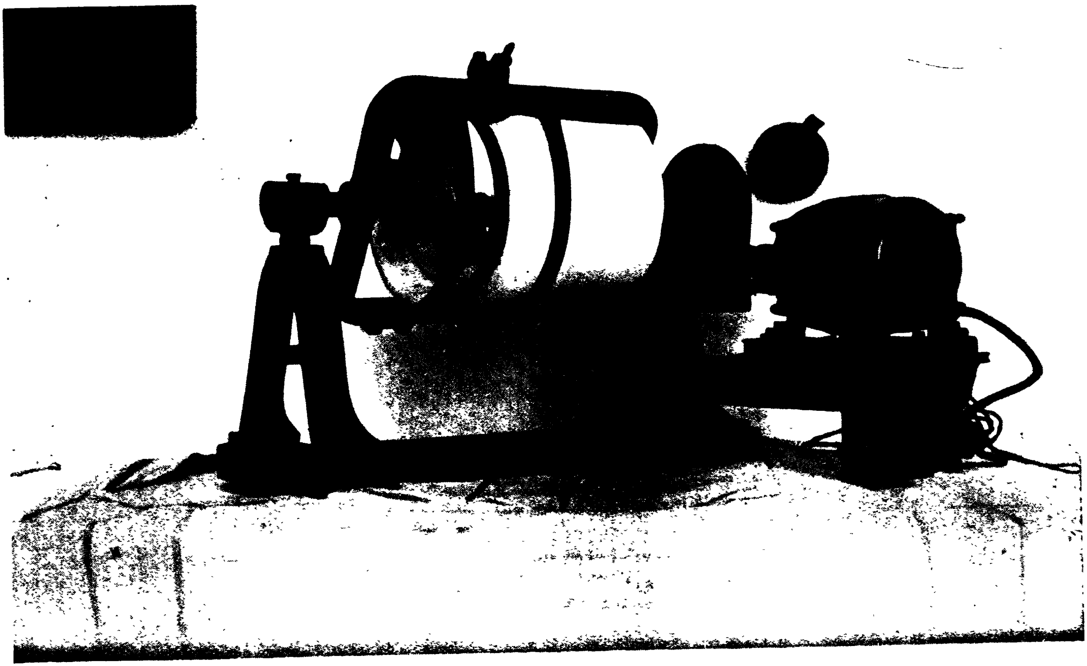

FIG. 14.

BALL MILL.
(Indian Lac Research Institute)

removes the dye with it. The grinding is repeated with fresh-water until no more dye can be extracted and the powder can pass through a 20-mesh sieve. By centrifuging a suspension of the powdered lac in water, suspended fine impurities are separated as a top layer and are removed. By repeating the centrifugal separation in a medium of salt solution (sp. gr. 1·2), the lac particles, effectively freed from impurities, separate as a top layer which is then washed and air-dried. The resulting seedlac is as free from alcohol-insoluble impurities as, and lighter in colour than, *shellac* obtained from the same sticklac by the usual process of manufacture but the yield is about 10% more. For further details the reader is referred to Bulletin No. 27 of the Indian Lac Research Institute.

As an adaptation of the above process to suit the conditions obtaining in the indigenous shellac manufacturing factories, a semi-large scale operation with 6 mds. of scraped lac was performed at the experimental lac factory of the Indian Lac Research Institute, Namkum. A description of this modification and its actual operation and costing are given below:—

Stage I. The scraped lac is first crushed by a stamping mill or by its local equivalent, *Dhenki* (Fig. 15) to a size to pass through a 20-mesh sieve. The crushing is best effected by a stamping mill, where power is available, but from actual experience, the ordinary country 'Dhenki' serves the purpose equally well. A unit of five women and two Dhenkis has been found to be able to prepare 6 maunds of 20-mesh scraped lac in 8 hrs. Assuming labour at 2½ as. per head, the cost of preparing 6 maunds of this material would be 2·1 annas per maund.

Stage II. After the scraped lac has been crushed to 20-mesh particles, as above, a maund of this material is introduced into a ball mill with flint balls with two maunds of water and 6 ounces of triethanolamine (price ½ anna per ounce) per 1·8 maunds of scraped lac. It can be hand-worked, but better by a 1½ H.P. electric motor. The ball mill is allowed to rotate for 1 hour, after which the seedlac is taken out and washed with water as long as there is any colour of the dye in the wash water. This intimate grinding in the ball mill loosens most of the mechanically adhering impurities and the soluble dye is also practically completely removed.

Instead of the ball mill, the ordinary country process of washing in stone vats in the presence of similar quantities of triethanolamine can also be resorted to.

Stage III. The washed lac is then removed to a circular cement vat which has a much larger surface area compared with its depth. A four feet diameter vat with a height of 2 ft. would easily handle several maunds in the course of a day. Common salt solution, previously prepared by boiling 37 seers of common salt with 100 seers of water and allowing to cool before use, is now poured into the

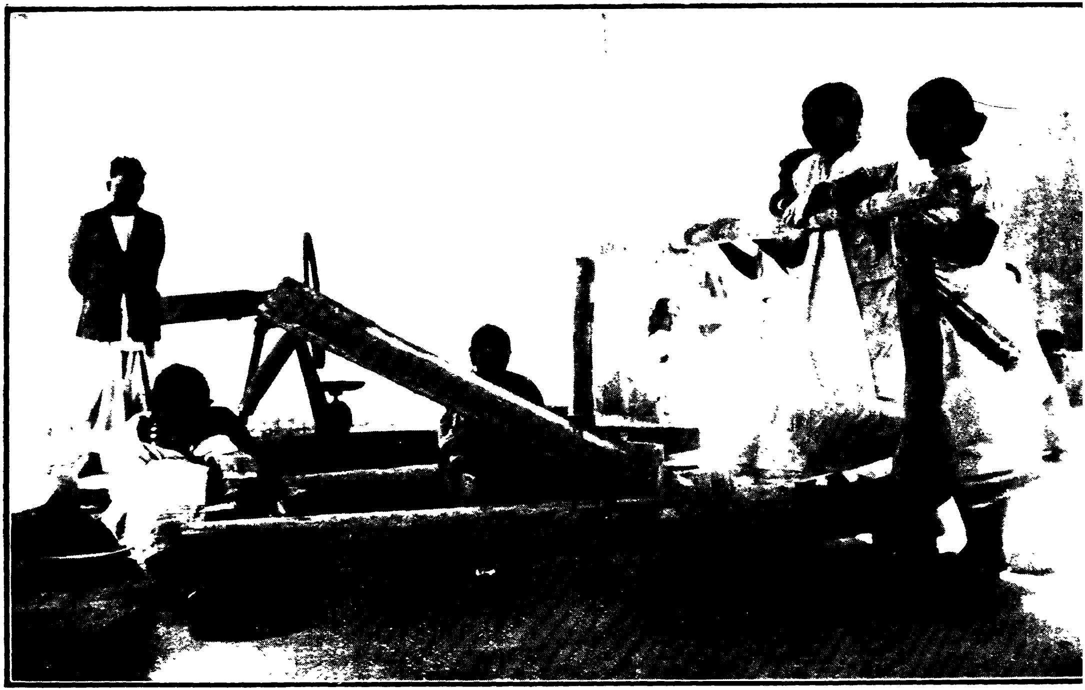

FIG. 15.

CRUSHING SCRAPED LAC IN "DHENKI".
(Indian Lac Research Institute.)

vat. The specific gravity of this solution is 1·2. This salt solution can be used many times, by separating suspended and settled impurities after every operation. The seedlac after being introduced is vigorously stirred in this salt solution by means of a wooden pole for five minutes and the whole allowed to stand. Impurities heavier than seedlac settle at the bottom of the vat, whilst purified seedlac floats on the top of the salt solution. The seedlac is removed by a wooden ladle, and placed in contact with clean water in another similar vat and stirred for a few minutes. On allowing the lac to settle, the lighter impurities like wood fibres, and insect residues float on top, whilst purified seedlac settles at the bottom. The seedlac is now separated by opening a bottom outlet and washed free from salt, which can be recognised by putting a few grains of seedlac on the tip of the tongue. The product is distinctly brighter in colour and purer in quality and has usually the following analytical figures:—

Cold alcohol insolubles	6·44%
Hot alcohol insolubles	1·1 %
Life under heat	31 minutes
Bleaching Test	45-50 c.c.
Colour Index	10-11

Cost of manufacture of one md. of refined seedlac from scraped lac:—

	Rs.	A.	P.
1·8 mds. of scraped lac @ 6/- per maund ...	10	13	0
Crushing of above	0	3	9
Washing by feet (one man)	0	3	6
Triethanolamine (6 ozs.)	0	3	0
Salt treatment	0	0	6
Washing by sedimentation	0	1	0
Overhead and other charges	0	2	0
Total Rs.	11	10	9

The price for such seedlac is at least 20% higher than that of the commonly exported commodity, and there is no chance of rejection as they may be considered invariably of such good quality as to pass the American Bleaching Test.

The existing practice of shellac manufacture gives rise to several by-products containing more or less of good lac, the most important of these being 'kiri' which is about 8% of the total shellac manufactured, and contains within it 50-60% lac. This product is now exported almost exclusively to Germany where the lac is freed from it and utilised in industries. Recent investigations at the Indian Lac Research Institute have shown the way to a successful recovery of lac from kiri; the method suggested has been in vogue

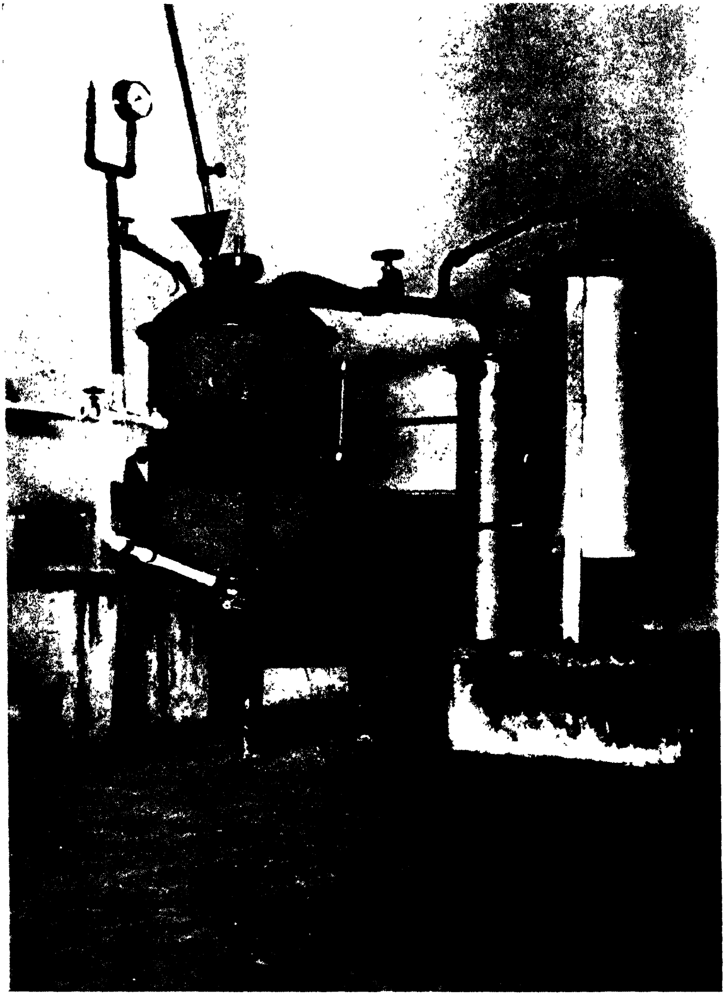

FIG. 16.

STILL FOR RECOVERING LAC FROM KIRI.
(Indian Lac Research Institute.)

for several years but was a closely guarded trade secret so far. A typical procedure is as follows:—

Two maunds (165 lbs.) of powdered kiri are soaked in 66 gallons of rectified spirit overnight and the supernatant solution is transferred to a steam-jacketed still (Fig. 16). Alcohol is recovered from the sludge as well as the lac solution by distillation and condensation. After practically all the alcohol from the lac solution has been recovered, the final traces of alcohol have to be removed by steam distillation until a test batch cools to a crisp mass. The molten mass is then run out and rolled into sheets. Garnet lac of good quality could be obtained by this process.

Plastic moulding

Mineral-filled shellac mouldings have been in use in the electrical industries (see *supra*) for a long time but wood-flour filled synthetic resin mouldings have now-a-days come into general use both for electrical and other uses. Investigations at the Institute have shown that several improved shellac compositions could be prepared. The following are a few typical compositions and their properties:—

	Composition			Properties
1.	Shellac	100	parts	Impact strength 4·8 cm.
	Wood Flour	100	,,	kg/sq. cm.
	Urea	6	,,	Heat resistance 81°C
	Calcium stearate	2	,,	Water absorption 1·9%
	Dye	2	,,	(24 hours)
2.	Shellac	30	parts	Impact strength 2·6 cm.
	Asbestos	65	,,	kg/sq. cm.
	Bone-black	5	,,	Heat resistance 81°C
	Urea	1·8	,,	Water absorption 0·08%
	Calcium stearate	1	,,	(24 hours)

The ingredients are mixed to a paste in the presence of alcohol and thoroughly dried before use. Trays, junction-boxes, containers for soaps, etc. (vide *frontispiece*), have been manufactured out of such compositions. The powders necessary for deep mouldings have, however, to be made up with larger proportion of lac to wood fluor to give the necessary fluidity under pressure and heat. For further details the reader is referred to Bulletin No. 30 of Indian Lac Research Institute.

Shellac moulding compositions have also been prepared by mixing shellac, fillers and small quantities of accelerating chemicals between hot rollers and moulding the mixed powders. A typical composition is as follows:—

Shellac	50	parts
Wood flour ...	35·5	,,
Titanium oxide ...	8·9	,,
Anhydrous oxalic acid ...	0·5	,,
Tricresyl phosphate ...	2·9	,,

Such compositions could be moulded into articles resisting heat up to 215°-280°F and details of procedure and data have been published in British Plastics (April 1935 and May 1935).

The chief drawback of shellac moulding is the longer time-cycle of the operation as compared with synthetic resin moulding of the bakelite type, since for the former the moulds have to be cooled before

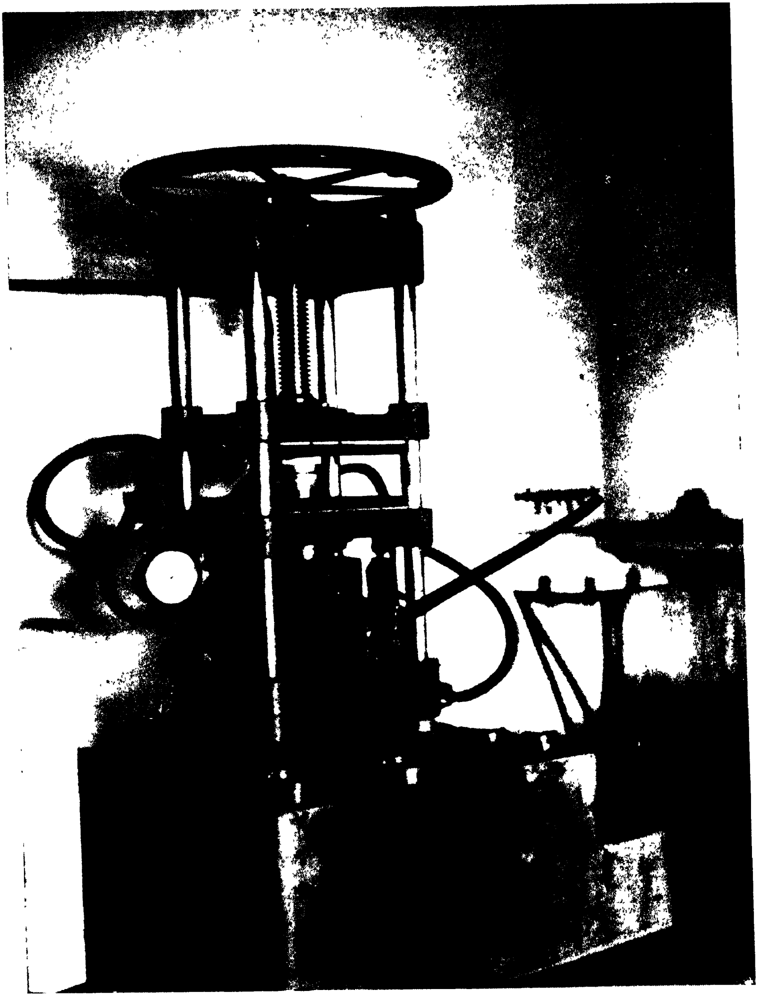

FIG. 17.

50-TON HAND-OPERATED HYDRAULIC PRESS WITH WATER-COOLED PLATENS.
(Indian Lac Research Institute.)

opening. One way of overcoming this difficulty is to use a number of portable moulds heated outside the press to the requisite temperature and using water-cooled press platens (Fig. 17). By this procedure the press need be engaged in pressure-cum-cooling for 2 minutes for every article.

An approximation to the bakelite-moulding technique can be achieved by using a modified shellac as the base for moulding powders and working at a mould-temperature of 120—130°C. The modification is effected by reacting shellac and formaldehyde at 120°C. for an hour; the product is then dissolved in rectified spirit and urea, wood-flour, colour, and lubricant are added. After refluxing for 2 hours, the spirit and the excess of formaldehyde are removed by distillation, the residual mass spread over for drying, and finally ground to 60 mesh. This is then further dried at 90—95°C. for 1½ hours, and moulded as in the bakelite technique.

A typical composition for such shellac moulding powders that could be worked on bakelite technique is given below:—

Shellac	400	parts
Formaldehyde (40% solution)	187·5	„
Urea	60	„
Rectified spirit ...	800	„
Calcium stearate ...	10	„
Wood flour	460	„

Standard moulded bars from such a composition has a shock resistance of 6 cm.kg. (V.D.E. Test). The heat resistance is 74-78°C. (Marten's Test). Using pure lac (α-lac *i.e.* the portion of shellac insoluble in ether) the shock resistance is considerably increased to 7·5 cm.kg. per sq. cm. and the heat resistance is 78-82°C. Complicated electrical mouldings like switches and junction-boxes have been prepared from such compositions and are in daily use in the laboratories of the Indian Lac Research Institute. Excepting the higher water-absorption and a slightly inferior gloss of these moulded goods, they compare very favourably with bakelite articles and could be produced somewhat cheaper.

Injection moulding:—With softer compositions of shellac as below, moulding powders suitable for use in injection moulding presses (Fig. 18) can be readily prepared (Research Note No. 19, Indian Lac Research Institute).

Shellac	6 parts
Wood flour	4 ,,
Urea	0·0 to 0·2 parts
Calcium stearate	0·1 parts

Pigment or dye (as required).

When moulded at 90°C., articles of good gloss and moderate strength can be made at the rate of 2 per minute. When moulded at higher temperatures, the surface becomes somewhat dull, which could be got over by polishing on a flannel buff.

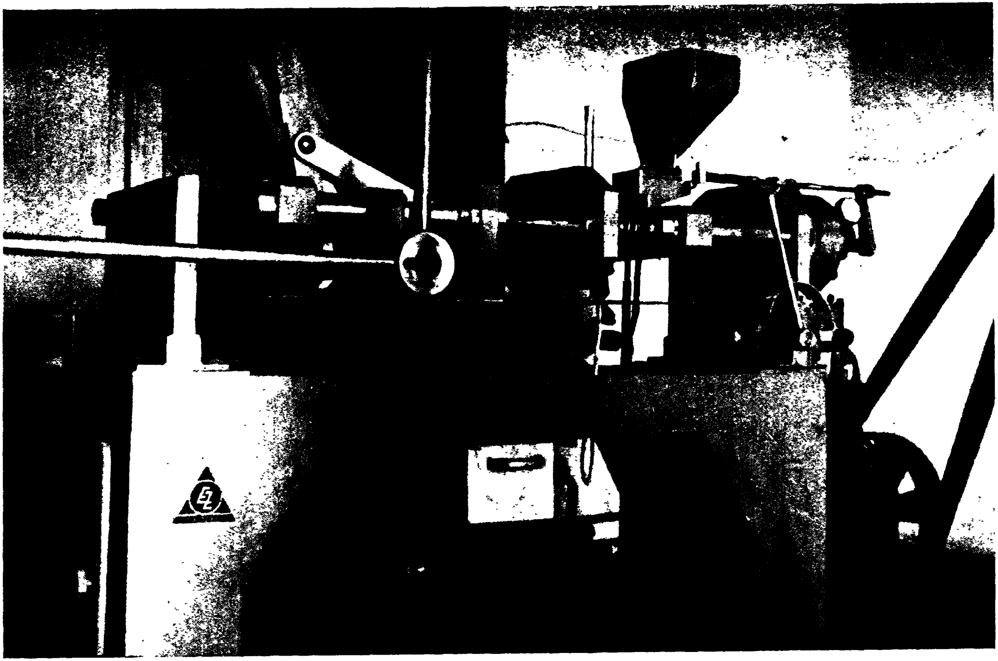

FIG. 18.

INJECTION MOULDING PRESS.
(Indian Lac Research Institute.)

Bleached lac

Bleached lac is used for incorporation in nitro-cellulose lacquers and for the preparation of colourless wood polishes. The bleaching of lac by chlorine has been practised for several years in foreign countries but the details of the procedure were not widely known. The process has been investigated at the Institute and the findings published as Technical Note No. 3. A typical procedure is as follows:—

1·5 lbs. of good bleaching powder (45% available chlorine) are stirred in 5 pints of water and in another vessel 1·3 lbs. of sodium carbonate are dissolved in 3½ pints of water. The soda solution is gradually added to the bleach suspension in portions until only a faint turbidity occurs on further small addtiions. The supernatant clear liquor is decanted off. The sludge is washed twice with 3½ pints of water each time and clear extracts collected. The decanted liquids finally made up to about 2 gallons will contain about 3% available chlorine.

Half a pound of sodium carbonate is dissolved in 4½ gallons of water and warmed up to 80°C. 4 lbs. of lac are slowly stirred in and after all the lac is dissolved, the solution is filtered through thin muslin cloth. To the filtrate is added another half-a-pound of sodium carbonate and warmed up again to 80°C.

To the lac solution maintained at 35°C. the bleaching solution is added in lots of 1-2 pints at a time until there is only a slight excess of unreacted chlorine in the mixture, and the solution is fairly well bleached. The solution is now diluted with water to twice its volume and dilute sulphuric acid (conc. acid diluted with 40 times its volume of water) is poured in a gentle stream, while continuously agitating the bleached solution by mechanical stirring, until all the alkali is neutralised. The granular bleached lac is washed thoroughly by several changes of water and dried in thin layers in a well-ventilated room or dried *in vacuo* at 40°C.

Hard and soft lacs

Shellac can be easily separated into various fractions with distinct properties and among these the most important are the 'hard lac' and 'pure resin' which can be separated from shellac by several processes.

1. The most well-known method is to completely extract lac with ethyl ether which leaves 70-75% of ether-insoluble but alcohol-soluble lac which has been called 'pure resin'.

2. By extracting lac five times with hot toluene a separation of soft and hard lacs is effected, the final residue containing about 63% pure resin and 11% soft resin on the weight of lac taken and has been called 'pure lac resin'. (Technical paper No. 5 of the London Shellac Research Bureau).

3. Another process for preparing hard lac is to extract lac with warm dilute sodium carbonate solution,

the product obtained consisting of a mixture of about 66% pure resin and 14% soft resin on the weight of lac used and has been termed 'sclerolac' (Technical Paper No. 13 of the London Shellac Research Bureau).

4. Shellac ground to 60-100 mesh fineness when exposed to gaseous ammonia and washed with water yields a hard lac containing 12-18% soft resin. An alternative method for preparing hard lac resin containing about 12% of ether soluble resin is as below:

Shellac is stirred with 1% ammonia solution in water at 15°—20°C, whereby a portion of the soft resin and colouring matters go into solution, leaving the hard resin as an ammonium salt insoluble in water at that temperature. The insoluble ammonium salt is dissolved in water at 50—60°C and allowed to cool to the ordinary temperature (25—28°C) when wax and other insolubles separate. These are removed by filtration through a paper pulp bed. The filtrate is now acidified with dilute sulphuric acid when the hard lac resin precipitates as a granular mass. The precipitate is thoroughly washed with water to remove any adhering sulphuric acid, and spread out in thin layers for drying. The powder is almost white in colour and has the following characteristics:

Acid value	56
Saponification value ...	210-215

Ether-soluble content	12%
Life under heat	7 minutes
Solution in alcohol is clear and does not 'green' copper on baking.	
Wax	1·7%

5. When a saturated solution of lac in acetone prepared at 25-30°C. is cooled in a refrigerator, hard lac containing 7-10% soft resin separates as a solid mass and can be freed by filtration. To a 40% solution of shellac in acetone is added 6-8% urea on the weight of shellac used and kept aside for 3 days, when the contents set to a hard jelly-like mass; the material is powdered and extracted with a few changes of acetone when hard lac resin containing urea and only 3·5% soft resin is obtained. The urea can be removed by extracting with boiling water. (Jour. Soc. Chem. Ind., June, 1938).

The importance of the above investigations lies in the fact that in many of the existing uses of lac the consumers are in search of improvements as regards heat- and water-resistance and absence of chemical action on metal surfaces, especially on copper. Hard lac resin is more heat-resistant, less water-absorbent, and its alcoholic solutions can be dried and baked on copper wire or foil without any chemical action on the metal. Moulded composite insulations of hard lac and usual fillers etc., withstand exposure to higher temperatures, without softening.

As a direct consequence of the above developments, a new problem has arisen *viz.,* utilisation of the soft lac resin obtained as a by-product. The uses that have been developed for the soft resin are described below:—

(1) If soft lac resin is heated with tung or linseed oil and a drier added in small proportions, a baking oil-varnish with useful properties can be produced (Technical paper No. 12 of the London Shellac Research Bureau).

(2) Soft lac resin could also be hardened by heating with 2·8% phosphoric acid at 150°C for 10-15 minutes or by heating it with 15-20% aniline at 120°C, cooling it to 60°C and again heating it at 120°C for 20-25 minutes with 15-20% paraformaldehyde. Such hardened products behave almost like ordinary shellacs in solubility, varnishing quality etc. By condensing soft lac resin with phenol or cresol and formaldehyde, using ammonia as catalyst, a product is obtained which is soluble in mixed solvents containing alcohol and benzene or cyclohexanol or other such high-boiling solvents. The resin is also soluble in drying oils to yield short-baking oil-varnishes (Paint Technology, Sept. 1938).

Polishes, Varnishes and Paints

Shellac is the most essential material for wood-finishes being used as 'French Polish' which is a solution of lac in methylated or industrial spirit. Till very recently, shellac could not be dissolved in drying-oils without profoundly altering its nature during the process, as for instance, in the manufacture of grinding Japans. Recent work of the lac research centres has improved the suitability of shellac for polishes and varnishes.

Instead of dissolving shellac in methyl or ethyl alcohol, if a mixture of ethyl alcohol and acetone (in the proportion 2 : 3) or methyl alcohol and acetone (in the proportion of 3 : 2) is used, the resulting varnish films are more resistant to water and the action of chemicals (Bulletin No. 2 of the Indian Lac Research Institute and Industrial and Engineering Chemistry, p. 912, 1930).

A shellac varnish from which wax is removed by filtration gives a brighter and more water-resistant film but the mechanical properties are poor unless the film is baked (Research Note No. 8 of the Indian Lac Research Institute).

A 40% of solution of shellac in industrial alcohol, filtered free of wax, and refluxed over a hot water-bath for 3-4 hours after adding 5% maleic acid yields superior varnishes with respect to adhesion, gloss, elasticity and water resistance. The varnish has no chemical action on copper. Coloured varnishes prepared by adding alcohol-soluble dyes to the above are fade-resistant on exposure to heat and light. As a result of such improvements, these varnishes are very suitable for lacquering aluminium or tin or lead foil, colouring electric bulbs, etc.

A very useful short-baking varnish has been prepared in the following way:—

If shellac (100 parts), formaldehyde (100 parts) and n-Butyl alcohol (100 parts) are heated together at 120°C for one hour using a reflux condenser, mixed formals are produced. The mass is then treated with 25 parts of urea and refluxed as before for 2 hours, and the excess of formaldehyde, butyl alcohol and water are distilled off under reduced pressure. The resin remaining behind after dissolving in a mixture of alcohol and benzene or toluene (1 : 1) can be used as a quick-baking varnish at 80-90°C. Wooden panels coated with the varnish are free from tackiness. When the varnish film is dried by a current of air at 45°-50°C, it is heat resistant in so far as it can withstand, without softening, the temperature of boiling water. Such films are also water-resistant.

Hard lac resin dissolved in alcohol gives a varnish with better adhesion and water-resistance than ordinary shellac and is recommended for lacquering the inside of tins for preserved fruits and as a wire enamel for the electrical industry (*Jour. Soc. Chem. Ind.*, Vol. 54, p. 82 T).

Water-proof varnishes have been developed by the New York Shellac Research Bureau by incorporating in shellac varnishes 1% urea and 5% of nitrocellulose, the latter dissolved previously in a mixture of ethyl alcohol and ethylacetate. In another example, wax-free bleached lac varnish is mixed with 10% nitrocellulose (½ second quality) dissolved in a mixture of ethyl alcohol and ethyl acetone (45 : 55).

By fusing shellac with 4-5% sulphur at 170°C, till a homogeneous mass is obtained, in about 30 minutes, a product is obtained which has improved properties. For example, varnishes from such a modified lac dry to harder and more water-resistant films and coloured varnishes can be produced by using very much smaller quantities of soluble dyes than would be required by ordinary shellac varnishes and lighter shades are possible since the lac-dye is almost completely bleached during fusion with sulphur. (Bulletin No. 18, Indian Lac Research Institute).

Shellac dissolved in ammonium bisulphite solution at 70°C can be used as a base for water-paints and as a component of various emulsified paint products. A typical formula is as follows:

100 parts bisulphite-lac (containing 30% lac and 4·5% ammonium bisulphite).
30 parts linseed oil.
380 parts lithopone.

Many colours and shades can be produced by suitable addition of pigments (Technical Paper No. 6 of the London Shellac Research Bureau).

A recent advance in lac-drying-oil varnishes is as follows: —

15 lbs. of linseed oil fatty acids are heated to 120°C and 15 lbs. of lac are gradually added with stirring until a homogeneous mass is obtained. 1-1·5 oz. of aluminium sulphate or naphthalene sulphonic acid and 3·25 lbs. of glycerine are added and the contents heated at 140°C for 3 hours. At this stage 1·5-1·75 oz. slaked lime, dispersed in a small quantity of the varnish is added, the vessel is removed from the fire and a suitable drier incorporated. The varnish can then be thinned with white spirit, solvent naphtha or toluene. The varnish yields good films especially on baking. (Technical paper No. 12 of the London Shellac Research Bureau).

Another process for the preparation of oil-varnishes suitable for water-proofing paper and cloth is to first prepare an acetyl derivative of shellac by heating 200 gms. of shellac with 45 c.c. of acetic anhydride and 455 c.c. of glacial acetic acid for 1 hour at 115°. The mixture is then distilled under reduced pressure at 115-140°C for 2 hours for recovering the acid reagents used nearly 90% of which can be recovered.

The acetylated product is treated with 100 gms. glycerine and 0·2 gms. para-toluenesulphonic acid and further distilled under reduced pressure raising the temperature to 250°C and maintaining that temperature for 4 to 5 hours. The product is then washed free of glycerine, acetic acid, etc. in boiling water. 500 c.c. of linseed oil are boiled for 30 minutes at 200°C with 5 gms. of litharge, and 100 gms. of shellac ester prepared as above are dissolved in it by raising the temperature to 250°C with frequent stirring in about 2 hours. When cooled, it is thinned with 100-150 c.c. of turpentine, filtered through muslin cloth and a small amount of cobalt linoleate is added. The varnish dries to a glossy film in 6 hours and possesses good water-resistance, adhesion, elasticity, and scratch-hardness. Paper, cloth, etc. coated with this varnish and dried or baked possess suitable suppleness and water-resistance. Experiments are in progress to find further new uses for the glyceride of acetylated shellac described above in combinations with cellulose acetate, rubber, etc. and as insulating varnishes. An alternative simplified process of making this varnish without the use of vacuum distillation consists in heating 200 grams of shellac, 5 c.c. acetic anhydride, 45 c.c. glacial acetic acid, 100 grams of glycerine and 0·2 grams of para-toluenesulphonic acid in an oil bath at 150-160°C till refluxing stops. The glyceride is now ready to be mixed with linseed oil as above.

Old infusible lac can be depolymerised by (*i*) autoclaving in presence of steam (Bulletin 19, Indian Lac Research Institute), (*ii*) by refluxing in contact with the usual shellac solvents in the presence of small quantities of mineral acids (Research Note 17, Indian Lac Research Institute), and by fusing with rosin (Research Note 7, Indian Lac Research Institute).

The easiest way is to hydrolyse shellac by alkali solutions and precipitate the mixed acids. These mixed acids could be brought within the range of use by condensing them with (*a*) aniline and formaldehyde or (*b*) phenol and formaldehyde. The condensed products could be used for preparing moulding compositions, or used as varnish in mixed solvents in the case of (*a*).

The Indian Lac Research Institute at Namkum, and the London Shellac Research Bureau with facilities for work at the laboratories of the University College, London, are fully equipped for service to the the present and prospective shellac-using industries.

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APPENDIX I

MANUFACTURE OF SHELLAC

After being cut from the tree, the lac may be sold for manufacture before the larvae have emerged, in which case it is known as *ari* lac ; or it may be sold after swarming, when it is called *phunki* lac. The process of manufacture consists of three steps. The lac is first scraped away from the stick by hand or in the case of Kusum lac, it is crushed in a roller-crusher, then crushed into small grains, and any pieces of stick removed by picking and winnowing. The next process is that of washing, to remove the insoluble impurities and the red-coloured lac dye, the resulting product being called seedlac. A certain amount of seedlac is sold, but the greater part is converted into shellac. This is done by melting it in long sausage-shaped cloth bags, about two inches in diameter, over a charcoal fire. During the heating process, the bag is twisted, and this pressure, combined with the heat, squeezes the melted resin material out through the cloth. The plastic mass is well basted by means of an iron spoon in order to mix its constituents, the resin and the wax. Then, if button-lac is being made, small quantities of the molten material are dropped on a zinc sheet, where they spread out into circular buttons about three inches in diameter and ¼ inch thick. If shellac is being made, a portion of the molten material is spread out in a thin sheet on the surface of a porcelain cylinder containing hot water. The thick sheet, so formed, is then removed and stretched into a large thinner one which is broken up when cold, the resulting flakes being the shellac of commerce.

This process, while fairly efficient, results in a number of by-products which sell at a low price and yet contain quite a high percentage of lac. Of these, the more important are *molamma,* a dust-like substance separated from the seedlac; *kiri,* the dirt and refuse which remains in the bag after the melting process and which is removed by splitting open the bag and lifting it out; and finally *passewa,* which is obtained from the cloth of the bags by boiling them after use, in dilute soda solution.

APPENDIX II

Specifications for Seedlac, Shellac etc.

Lac is exported to other countries chiefly in one of five forms viz., shellac, button-lac, seedlac, sticklac, and refuse lac. Generally, the price of each consignment is subject to mutual agreement betwen the buyer and the seller after inspection of a sample by the buyer. There are also several accepted standards, the best known being those adopted by the United States Shellac Importers' Association. These are as follows:—

Orange Shellac.	Grade. A.	Grade. B	Grade. C	Grade. D
Iodine number, maximum ...	18·0	18·0	18·0	24·3
Matter insoluble in specified hot solvents, maximum, per cent.	1·75	2·50	3·00	3·00
Moisture,, maximum, per cent. ...	2·0	2·0	2·0	2·0
Wax, maximum, per cent. ...	5·5	5·5	5·5	5·5
Matter soluble in water, per cent.	0·5	0·5	0·5	0·5
Ash, maximum, per cent. ...	1·0	1·0	1·0	1·0
Colour	The colour shall be equal to that of a sample mutually agreed upon by purchaser and seller.			

Seedlac.	*Kusmi*	*Baisakhi.*	*Rangoon.*
Iodine number (on lac free from alcohol insoluble matter), maximum	18·0	18·0	18·0
Matter insoluble in hot 95% alcohol, maximum per cent.	3·0	5·0	5·0
Moisture, maximum per cent. ...	2·0	2·0	2·0
Matter soluble in water, maximum per cent.	1·0	1·0	1·0
Wax, maximum per cent. ...	5·0	5·5	5·25
Ash, maximum per cent. ...	1·0	1·0	1·0
Colour	The colour shall be equal to that of a sample mutually agreed upon by purchaser and seller.		

The Association publishes periodically details of the methods of analysis in force at the time.

It has been the experience of most shellac consumers that although the official specifications check the degree of purity of a sample, they do not indicate the thermoplastic condition which is determined by the length and conditions of storage, traces of chemical reagents introduced during manufacture etc. Hence many private firms purchase on an additional test known as the 'flow test' which gives an arbitrary measure of the fluidity of the sample when kept at a particular temperature (Generally 100°C., 105°C. or 125°C.) and inclined at a definite angle (15° or 45° or 60° to the horizontal).

In several industries, notably in the gramophone record industry, the length of time for which a sample of lac will maintain its plasticity is an important factor not indicated by its degree of purity found by the usual tests. The Westinghouse Electrical Co. Ltd., have adopted a test for determining the 'life' at 150°C and the American Society for Testing Materials has adopted a similar test as a tentative standard (*vide* Proc. of the A. S. T. M. 1935).

A standard for colour is long overdue in order to save time or misunderstanding between buyers and sellers and several methods of comparison with standard strengths of iodine, dichromate or other solutions are being tentatively tried by several firms.

Practically all the seedlac exported from India is used up by the bleached lac industry and the existing specifications for seedlacs are not of much help to the industry as insolubles and original colour are less important than bleachability. A test for bleachability that would be acceptable to both sellers and consumers is under investigation.

ERRATA

Page	Line	For	Read
11	15	charing	charging
13	18	is used	was used
40	11	acqueous	aqueous
41	17	buffiing	buffing
51	14	practiced	practised
58	6	with larger	with a larger
58	7	fluor	flour
74	24	omit the words 'in a thin sheet'	